ON THE ADMINISTRATION OF "SMALL" ENERGY CONSERVATION PROJECTS IN COMMERCIAL BUILDINGS

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ABSTRACT

The administration of small energy conservation projects (i.e., projects costing between $1,000 and $20,000) can present a difficult challenge for those responsible for energy management in commercial buildings. In order for small projects to remain cost-effective, administration costs must be held down, but small projects are often nearly as complicated as larger projects. Thus, when the City of Berkeley obtained $225,000 for the purpose of undertaking a number of small energy conservation projects, it quickly became clear that the efficient use of limited administrative resources would be very important.

This report describes Berkeley's strategy for project administration and discusses some of the problems associated with this strategy. A central feature of this strategy was the use of combined audit - design - construct - maintain contracts. We conclude that contracts of this type can be used successfully provided that a careful, independent technical review is conducted in each phase of the contract. We also report some of the savings obtained in the few months since the completion of the projects.

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INTRODUCTION

From the ivory tower it looks simple. First, an audit identifies an energy saving opportunity, then an engineer develops plans and specifications for a retrofit, next a contractor installs the retrofit, and finally the maintenance staff keeps it all running in good order. Energy and money saved! The energy officer basks in a warm glow of approbation.

Sadly, this rosy picture is contrary to much experience. In what follows, we describe some of the reasons why saving energy is harder than it looks and offer some suggestions for getting around the difficulties. Our report is based on our experience in planning and managing a number of small energy conservation projects in buildings owned by the City of Berkeley.

First, we discuss some of the problems with the audit - design - construct - maintain process when each step of the process is performed by an independent party. These problems derive from weaknesses in the process and from the potential for high administrative costs. Next, we describe Berkeley's approach to solving these problems by combining the steps and employing a single contractor. Our experience in employing this approach revealed some new problems. We describe these problems along with our efforts to solve them. We also report some early (and satisfying) results from the completed projects. We conclude with some suggestions for those who may wish to employ an approach similar to Berkeley's for other energy conservation projects.

The Problems

The apparently straightforward progression from energy audit to retrofit design to project construction to maintenance is made difficult by several problems. When the energy conservation projects involved are "small" (i.e., approximately $20,000 or less), the most serious of these problems is the potential for administrative costs that are high relative to the project costs. If each of the stages is conducted by a separate contractor then four contracts must be negotiated. In the municipal context, this can involve a considerable amount of paperwork since municipal governments usually have rather rigid procurement procedures designed to prevent political hanky-panky in the award of contracts. After the contracts are awarded, the project manager must communicate with and coordinate the efforts of several individuals. This takes time and can be quite frustrating, especially when the interests of these individuals come into conflict with one another.

A second serious problem is a lack of clear standards for judging the quality of an energy audit. When an auditor is hired for a fixed fee, there are obvious incentives to complete the task expeditiously. How is one to know whether or not the auditor has

proceeded too quickly and has not found what should have been found? Moreover, haste can lead to sloppy work. However, to our knowledge, no auditor has ever been held to account for inaccurate estimates of the cost of conservation measures or energy savings from conservation measures. In the municipal context, when there may be considerable pressure to select the low bidder, the bad auditors can drive out the good. That is, the sloppy worker can underbid the careful worker since the former cannot be held to account for his sloppiness.

The Berkeley Context

The City of Berkeley has a population of approximately 100,000. Located on the San Francisco Bay due east of the Golden Gate Bridge, it has a mild climate (approximately 3,000 heating degree days). The largest employer is the University of California and there is a large student population. Among other things, the city is noted for restaurants serving "California cuisine," good bookstores, and liberal politics (only 20% of the voters cast their ballots for the Republican candidate in 1984).

The city's business is conducted by a city-manager form of government. An elected council has the legislative authority. Citizen advice is provided to the council by a number of boards and commissions. An energy commission was established in 1976 and an energy office with professional staff was established in 1980. The city operates 42 facilities, including senior centers, libraries, fire stations, recreational facilities, an office building, and a jail. The energy cost of operating these facilities is about $600,000 per year.

During the latter half of 1983, the Berkeley Energy Office was able to obtain $38,500 in funding under a contract with the California Energy Extension Service to establish an energy management program for the city. Also participating in this program were the neighboring cities of Albany and Emeryville. The first phase of this program was devoted to obtaining and organizing data involving energy use and costs as well as facility operations. This involved assembling records from the utility (Pacific Gas and Electric Company (PGandE)) on energy consumption and from city files on its facilities to obtain a picture of the energy use patterns. This was followed by some preliminary efforts to identify opportunities for cost-effective energy-conservation improvements in the facilities.

The preliminary work was sufficiently encouraging that a decision was made to seek funding for some energy improvements. A request for proposals (RFP) was issued inviting prospective contractors to propose improvements and methods for financing them at six major city facilities. At the time the RFP was issued, a form of private "third-party" financing such as a shared-savings agreement was thought to be the most appropriate financing method. Four proposals were received and a review process was initiated that lead to the identification of two contractors likely to provide the best services. One contractor specialized in the area of lighting and the other in mechanical systems.

The review process involved the participation of the city's Departments of Finance and Public Works. The Finance Department raised questions as to why there was any need to share the substantial savings from energy conservation measures with a

contractor. The decisive reason for offering to share the savings would have been to compensate the contractor for providing the capital to undertake the projects. Since the Department of Finance would be responsible for any alternative arrangements for financing the proposed projects, the questions that the Department raised placed it in something of a "put-up-or-shut-up" position. Much to its credit, the Department not only kept talking but also developed an alternative financing package. As part of an existing plan to finance capital improvements for the city, $225,000 was allocated for energy conservation. This financing program used instruments known as "certificates of participation" which are similar to municipal bonds. Energy savings were pledged as part of a guarantee of repayment to the certificate holders.

Now the ball was back in the Energy Office's court. Likely targets for energy-conservation improvements had been selected, contractors had been identified, and funds had been allocated. It was up to the Energy Officer to deliver the goods.

The Berkeley Strategy

The problem that now confronted the Energy Office was how to develop efficient contractual arrangements for obtaining the desired services. We considered the option of dividing the tasks into separate contracts. An advantage of this approach is that it is similar to standard industry procedures in which design and construction are kept separate. This similarity would make the preparation of contracts more straightforward and create a situation in which there might be fewer misunderstandings among the participants since the process was familiar. Another important reason for separating design and construction in fixed price contracts is that in combined design - construct contracts there is an incentive for the contractor to bias the design toward low-cost construction. This can increase the contractor's profits but it may be at the expense of job quality.

However, as noted earlier, a major drawback of the separate contracts approach is the high cost of negotiating and administering the contracts. Since the Energy Office had only one full-time staff member and had a number of other responsibilities, it was important to minimize the administrative work load. Thus, we decided to negotiate comprehensive contracts with the two firms that had been identified in the RFP.

These contracts were designed to be conducted in four phases:

1. detailed technical energy audits,

2. engineering, including plans and specifications, for energy conservation measures selected by the city from the results of the energy audits,

3. installation of measures engineered in phase 2, conditioned on city approval of the design and the costs, and

4. monitoring, maintenance, and training.

In addition to combining the steps in the process, these contracts also involved combining projects in several facilities. The contractor specializing in mechanical work was

assigned four buildings: two senior centers, the Civic Center (an office building), and the Hall of Justice (police station and jail). The contractor specializing in lighting was assigned three facilities: the main library, the Civic Center, and Live Oak Park (indoor and outdoor recreational facilities). The terms of the contracts did not prohibit the mechanical contractor from proposing lighting measures or the lighting contractor from proposing mechanical measures.

The contracts were not fixed price. Instead, they specified an amount not to be exceeded. The contractors were initially authorized to spend 5% of this amount for energy audits. This was to be followed by a review of the audits and a selection of projects for design. Then the contractors were to be authorized to spend 5% of the estimated project costs for design. The design was to produce plans and detailed specifications and final cost estimates. Another review followed the design. Projects approved in this review were then to be constructed. Ten percent of the contract funds were reserved for post-installation support. The city was not committed to expending all of the contract funds. The funds would only be expended if the city approved a sufficient number of conservation projects.

We felt that these arrangements would have an additional advantage in that by contractually linking energy audits to the rest of the process we would increase the incentives for doing good work in this phase. There were two reasons for this. First, good work in the audit phase greatly simplifies the work in the design phase. Second, failure to do a thorough job in the audit phase might produce an insufficient number of projects approved for design and construction (insufficient, from the contractor's point of view, in that not all of the contract funds would be spent).

It was clear from the outset that good review processes at the end of the audit and engineering phases would be important because, in addition to their good features, the contracts also created some perverse incentives. In particular, there were incentives to inflate both savings estimates and cost estimates. Inflated savings estimates might lead the city to undertake unneeded projects and inflated cost estimates, if accepted, would increase the contractor's profits. To undertake the necessary reviews, we established a group consisting of Elroy Holtman, an electrical engineer and the city's Chief of Facilities and Maintenance, Gerald Kasin, a mechanical engineer and member of the city's energy commission, and the authors.

Berkeley's Experience

As discussed above, two contractors were retained, one whose strength was in mechanical systems and the other specializing in lighting systems. We focus first on our work with the mechanical contractors. The majority of our funds were spent on mechanical retrofits, this work was more complex than the lighting work and was the source of most of the problems that we had to confront.

We had, we thought, thoroughly explained the workings of the contracts to our contractors and had obtained their full agreement to the terms. Thus, we were more than a little surprised when, without prior meetings or discussion, the mechanical contractor submitted a list of proposed measures for the two senior centers together with undocumented estimates of installation costs and energy savings and asked for

approval to begin construction! We reviewed the terms of the contract with the contractor again and made it clear that we did not intend to proceed to construction without thorough reviews of the audits and designs.

Subsequently, we spent many hours in numerous review meetings with the mechanical contractors. These meetings led to many changes in the contractor's proposals. Audit recommendations were rejected and designs were altered (sometimes radically). But, the underlying tension between the contractor and the city caused by the contractor's desire to move rapidly to the construction phase was never really resolved. We wanted to be sure that what was undertaken would really work; the contractor's attitude seemed to be that, if there were problems, they would be resolved during the construction phase, "in the field" as it was called.

In retrospect, we are convinced that the review process was very important to the success of the contract. Not only the city, but also, we believe, the contractor benefited from the reviews. For example, one review meeting established that a proposed heat-recovery scheme could not work. Had the proposed device been installed, the contractor would have had a hard time collecting his fee.

In spite of the tension between the contractor and the city, we were generally satisfied with the workmanship on and results from the measures installed. Table 1 summarizes these measures and their costs.

A large share of the funds were spent on the installation of new boilers and water heaters. The two senior centers were "all electric," apparently as a requirement of federal funds used in their construction. (The buildings were constructed in the mid-1970s when shortages of natural gas were thought to be imminent.) We converted the space and water heating in these buildings to natural gas and the job costs include bringing gas service to the buildings. In each of the senior centers we used three condensing hot water heating units, manufactured by Weil-McLain, for space heating. Each unit is rated at 150,000 Btu/hr. The units are fired sequentially as required by the heating load. In the North Center we kept the tanks of the existing resistance hot water heaters and installed a copper coil heater to create a gas-fired, circulating-tank system. In the South Center, which had an indirectly heated storage system, a new gas-fired storage heater was installed.

We had not envisaged replacing the boiler at the Hall of Justice when we initiated our contracts. However, a crack was discovered in one of the sections of the existing boiler and, since replacement was indicated, we decided to install efficient equipment. A forced-draft, water-tube boiler manufactured by Ajax and having a capacity of 2,000,000 Btu/hr was selected.

The Hall of Justice boiler replacement illustrates a problem that we encountered several times in the course of our work. That is, it is sometimes difficult to separate safety and reliability from energy conservation. This is particularly true with older facilities where aging plumbing and wiring can make retrofits difficult. It is all too easy for costs of conservation projects to rise substantially because of the need to pay for "deferred" maintenance. We have come to believe that some expenditure for deferred maintenance is almost inevitable in older facilities. Thus, increased costs must be anti-

Table I. Energy conservation retrofits by the mechanical specialists.

Description	Installed Cost ($)
North Berkeley Senior Center	
Replace electric boiler and domestic hot water heater with natural-gas fired units (includes costs to install gas service)	21,600
Install new heating controls, install controls for A/C economizers	3,900
Insulate hot water tanks and pipes, chemically clean evaporator and condensor coils	1,700
Sub total for North Senior Center	27,200
South Berkeley Senior Center	
Replace electric boiler and domestic hot water heater with natural-gas fired units (includes costs to install gas service)	28,200
Install new heating controls, install new A/C controls	7,900
Insulate hot water pipes, install refrigerator lining, install locking covers on thermostats, chemical clean evaporator and condensor coils	1,900
Subtotal for South Senior Center	38,000
Hall of Justice	
Install new space heat boiler	24,400
Install thermostatic valves and repair or replace traps on 58 radiators	21,200
Insulate condensate return lines, insulate all hot pipes in boiler room	10,900
Install new flue and IID on domestic hot water boiler	2,000
Install economizers on 3 A/C units	4,600
Audit and design fees for measures not authorized for installation	1,300
Subtotal for Hall of Justice	64,400
Civic Center	
Install optimum start/stop device on space heat boiler	2,900
Install time-of-day controls on 4 package heating and cooling units and on domestic hot water recirculation pump, install IIDs on 2 package heating and cooling units	2,500
Tune up space heat boiler, clean evaporator and condensor coils on A/C units	1,100
Subtotal for Civic Center	6,500
Total for all facilities	136,100

cipated. They lengthen the period for payback from energy savings but also provide benefits in increased reliability and safety.

Our contract with the lighting specialists went somewhat more smoothly than the contract with the mechanical specialists. The contract phases proceeded in a more orderly fashion, much less time was required in the review process, and there was less tension between the contractor and the city. It is difficult to assess how much of this difference was due to differences between the lighting and mechanical contractors in attitude and approach. Certainly, we were impressed with the professionalism of the lighting specialists. However, other factors probably also contributed to making the lighting work less difficult. Lighting retrofits are typically modular. That is, they involve repeated applications of the same measure such as the installation of reflectors. Thus, it is possible to make a test installation of a few retrofits to see how well they work. Because we were able to do this kind of testing, we felt the design phase for lighting retrofits was a little less critical than it was for mechanical retrofits. Another factor that may have influenced the quality of the process was that the lighting contractor did not have his own construction crews; installations were performed by subcontractors. This meant that there was no pressure to speed the process in order to keep work crews occupied. We believe that a desire to keep work crews employed may have been one of the reasons for the tension between the city and the mechanical contractor.

Table II summarizes the conservation measures installed by the lighting specialists and their installation costs. The largest expenditure was for the installation of reflectors and delamping at the Civic Center. The cost of this work was increased by the need to replace some old ballasts and some old wiring. Other measures included the installation of motion detectors and the replacement of outdoor incandescent lighting with HID lamps.

Early Results on Energy Savings

Most of the work on the installation of the conservation measures was not completed until the first quarter of 1986. Thus, results on energy savings are still fragmentary. Based on the information available, we believe that the simple payback period for Berkeley's investments will be on the order of four to five years.

The first installations to be completed were at the two senior centers. Five months of operation (from mid-October to mid-March) at the North Berkeley Center yielded savings of about 53,000 kWh in comparison to the previous year. This was partially offset by new gas consumption of about 2,250 therms. The net savings were worth approximately $3,800. The results are about what one would anticipate from the replacement of electricity by gas (2,250 therms approximately equals 66,000 kWh). We expect that savings for the balance of the heating season as well as year-around savings for domestic hot water will bring annual savings to about $6,000 - a five year simple payback.

Four months of operation (from early November to early March) at the South Berkeley Center yielded savings of about 83,000 kWh in comparison with the previous year. This was partially offset by new gas consumption of about 1,700 therms. The net

Table II. Energy conservation retrofits by the lighting specialist.

Description	Installed Cost ($)
Civic Center	
Delamp 286 fluorescent fixtures from 4-tube/2-ballast to 2-tube/1-ballast	1,900
Install 528 optical reflectors on fluorescent fixtures and delamp to 2-tube/1-ballast	31,000
Install 28 motion detectors	6,800
Install 7 daylight dimming devices	2,600
Subtotal for Civic Center	42,300
Live Oak Center	
Install 16 fluorescent fixtures and tubes to replace indoor incandescents	4,600
Install 12 250-watt metal halide fixtures to replace outdoor incandescents	4,900
Install 3 intermittent ignition devices	700
Install 4 Strato jet ceiling fans	600
Subtotal for Live Oak Center	10,800
Total for both facilities	53,100

savings were worth approximately $6,000. The results are much better than would be anticipated simply by replacing electricity with gas (1,700 therms approximately equals 50,000 kWh). We expect the savings for the remainder of the first year of operation will be at least equal to those of the first four months, giving a simple payback of a little more than three years.*

We believe there are two reasons why results at the South Center were better than those at the North Center. First, results of the energy audits suggested that operations at the South Center were not being as carefully managed as those at the North Center and we concluded that a larger investment in controls was warranted for the South Center. Second, the domestic hot water heater at the South Center was indirectly heated, using hot water from the space-heat boiler. This required the boiler to operate all day, even when heating was not required. The effects of this were especially noticeable in the summer. We believe the results obtained at the South Center are consistent with other experience to the effect that, in appropriate circumstances, improved controls can be very cost effective (Energy Users News) and that indirectly-fired domestic hot water heaters are often very wasteful.(Dubin et al., 1976)

CONCLUSION

In the introduction we promised to offer some suggestions for those who might wish to employ an approach similar to Berkeley's for other energy conservation projects. The first point to address is whether we ourselves would be prepared to try this approach again. Our answer is an equivocal yes. The approach is far from perfect but the alternative of unbundling the steps in a conservation retrofit still seems to us to be prohibitively cumbersome.

Our primary recommendation to those who may wish to follow the Berkeley approach is: don't underestimate the difficulties. While some administrative snarls are avoided, there are still many problems to deal with. This takes time. Be prepared to spend it. Independent expert advice, such as was provided by our review committee, is essential. This should be arranged for before a contract is signed. If the needed advice cannot be obtained from volunteers (as in Berkeley), then it should be hired. It will be well worth the money.

A second recommendation is: work hard to maintain good communication with the contractors. If the contractors don't keep you informed of what they are doing, complain. Do this even if there are no obvious bad consequences from the poor communications. Our favorite story of poor communications concerns a retrofit of controls on a package heating and cooling system. This system served a conference room located next to the offices of the members of the city council. Without informing us, the contractor began work on this system one afternoon but did not return to finish the job until a couple days later. Meanwhile, when some council members and others arrived at

* These estimates, and those for the North Center, may be a little optimistic since the previous year was somewhat colder. We think that weather correction would probably reduce the savings estimates by between 5 and 10 percent.

the conference room for a meeting, the temperature was in the low fifties. It wasn't funny at the time.

While the above recommendations can help to make conservation projects more successful, they cannot solve the most serious problem. That is, what is really needed is not yet on the market or is at least very hard to find. Ideally, one would like to hire a "full-service" energy management contractor who is expert and reliable in all phases of the business and in all conservation technologies. In fact, the world is filled with specialists who know one or another of the phases of the business and who are expert in only a few conservation technologies.

In part, this problem may be a result of the fact that the business of providing conservation services is an infant industry. As the providers of these services gain experience, their knowledge may broaden sufficiently to make them much better approximations of the "full-service" ideal. However, there may be practical limits to the expertise that can be obtained by a single service provider. Other kinds of mechanisms for obtaining "full-service" may evolve as the industry matures. For example, we see a potential role for energy service project management firms. Such firms would be generally knowledgable about the phases of the business and the technologies but their real expertise would lie in finding and deploying the right experts. While we wait for this or another better mechanism to evolve, it is fortunate that energy conservation investments are very profitable. We can afford to make some mistakes and "learn by doing."

REFERENCES

Dubin, et al. How to Save Energy and Cut Costs in Existing Industrial and Commercial Buildings. Noyes Data Corp., Park Ridge, NJ. 1976, p. 397.

Energy User News, Fairchild, New York. Virtually every issue of this periodical has information on the applications of improved controls.